favorable. For while it frequently happens at all times of year that there is a layer of strong wind between 1,500 and 2,000 feet, with weaker winds above and below, the decrease aloft is generally small except in summer. In winter and spring the least resistance will generally be met by flying as low as practicable.

In conclusion it may be said that the southern plains States offer a favorable field for flying activities. The country is open and mostly free from mountains. Visibility, the most important meteorological element in flight, is generally satisfactory. On the visibility scale, running from zero for dense fog to 9 for perfectly clear air, the visibility most frequently recorded is 7. As an example of excellent visibility it may be cited that a pilot balloon at Broken Arrow was followed with two theodolites to a distance of more than 50 miles, and when the balloon disappeared it was less than 6° above the horizon.

Dense fog is the most serious obstacle but interruption of flight by dense fog in this region is very infrequent. Thunderstorms are a serious handicap; they cause delays by compelling the aviator to fly around them; statistics show, however, that thunderstorms are less frequent in this region than in some other States except perhaps in May and June. Low clouds and rain present the most frequent unfavorable condition, and often necessitate flying near the ground.

The schedule of the Air Mail for this portion of the route is so arranged as to gain the greatest benefit from the daily changes of wind; northward flight in the morning is frequently advanced by the prevailing strong south winds; southward flight is less frequently delayed in the afternoon because wind speeds are then at their lowest rates. The greatest percentage of delayed trips may be expected when southward trips are made in the early morning.

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THE CORRELATION BETWEEN SUN-SPOT NUMBER AND TREE GROWTH

551.590.2 : 634

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There is at present evident, in both the scientific and the popular press, a widespread interest in the possible relationship between solar activity and terrestrial phenomena.

Such interrelationships, if they exist at all, can best be demonstrated and their intensity measured by the determination of the correlation between some measure of the sun's activity and terrestrial variables.

The only measure of solar activity available for a protracted period of time is that of the sun-spot relative numbers. The most usable measures of terrestrial phenomena which might possibly be influenced by solar variation are the instrumentally determined values of temperature, precipitation, barometric pressure, and other meteorological phenomena and the record of the rate of plant growth as embodied in the trunks of trees.

A review of the extensive literature on the supposed relationship between solar activity and climatic factors and plant activities falls quite outside the scope of the present note, which has for its purpose merely the presentation of the actual correlations between the annual means of the monthly observed relative sun-spot numbers (s) as given by Wolfer (*1*)[1] and the annual ring (r) measurements on trees from various parts of the world as given by Douglass (*2*).

Because of the great variability of both sun-spot numbers and ring diameters it is difficult to secure a system of grouping either variable which may not introduce an appreciable error into the end results. The coefficients of correlations, and the antecedent means and standard deviations, were computed from the original sun-spot numbers, s, of Wolfer and the ring measurements, r, of Douglass by the formula (*3*),

$$r_{sr}=[\Sigma(sr)\ /N-\bar{s}\ \bar{r})]\ /\ \sigma s\ \sigma r$$

without grouping of either of the variables. The coefficients are; therefore, numerically absolutely correct, barring the possibilities of arithmetical error which has not been detected in the checking of the coefficients.

The coefficients shown in the accompanying table[2] are generally low. Three of the fifteen values determined from the whole series of data are negative in sign. The ratios of the coefficients to these probable errors are over 2.00 in only 8 of the 15 cases.

TABLE I.—*Correlations between Wolfer's mean sun-spot relative numbers and tree-ring diameters as recorded by Douglass*

Series and locality	Period	Correlation and probable error $r \pm E_r$	r/E_r
I. Flagstaff, Ariz.	1749–1910	+0.099±0.053	+1.87
II. South of England	1859–1912	+.265± .085	+3.10
III. Outer coast of Norway	1828–1912	+.174± .071	+2.45
IV. Inner coast of Norway	1820–1908	−.126± .070	−1.79
V. Christiania, Norway	1820–1912	+.071± .070	+1.02
VI. Central Sweden	1820–1910	+.109± .070	+1.57
VII. South Sweden	1820–1910	+.159± .069	+2.30
VIII. Eberswalde, Prussia	1830–1912	+.487± .056	+8.64
IX. Pilsen, Austria	1830–1912	+.096± .073	+1.30
X. Southern Bavaria	1848–1911	+.241± .079	+3.04
XI. Old Norway trees	1749–1835	−.164± .071	−2.31
XII. Old Sweden trees	1749–1835	+.317± .065	+4.84
XIII. Windsor, Vt.	1749–1912	−.076± .053	−1.45
XIV. Oregon group	1749–1911	+.157± .052	+3.03
XVI. Sequoia (group of 1915)	1749–1914	+.010± .053	+0.19
I. As above	1749–1829	+.073± .075	+0.97
I. As above	1830–1910	+.160± .073	+2.19
XIII. As above	1749–1829	−.272± .070	−3.89
XIII. As above	1830–1912	+.057± .074	+0.77
XIV. As above	1749–1829	+.395± .064	+6.20
XIV. As above	1830–1911	+.143± .073	+1.97
XVI. As above	1749–1829	+.091± .075	+1.22
XVI. As above	1830–1914	−.078± .073	−1.07

There are, however, unmistakable evidences for a positive correlation between the two variables. While the coefficients are admittedly low, 12 of the 15 coefficients deduced for the series of data as given by Douglass are positive in sign. Of the eight values which are over twice

[1] The observed, not the smoothed, numbers were invariably used.

[2] The Series I–XVI correspond to the tables given in the appendix to Douglass's volume. The Series XV is omitted because it falls wholly outside the period of sun-spot record. The Series I, XIII, XIV, and XVI are treated both as entities and subdivided for reasons indicated in the text.

as large as their probable errors, all but one are positive. The average value of the 15 coefficients (regarding signs) is +0.1212. Furthermore, two of the negative coefficients (IV and XI) are based on measurements from the same general region and are deduced from data emphasized as far from satisfactory by Douglass himself. The third series which indicates a slightly negative relationship (XIII) is noted by Douglass as having apparently been subject to a profound change in environmental conditions during the course of development.

On the other hand it is interesting to note that the four longer series (I, XIII, XIV, XVI) which cover the entire period for which sun-spot numbers are available, and which in consequence should be expected to show the highest correlations, actually show some of the lowest coefficients available. These have been subdivided into two periods, with a view to determining whether the inferior accuracy of the sun-spot numbers in the earlier years might be the source of the lower correlations for the longer periods of time.

Since a number of the other series cover the period 1820–1830 to 1910–1920, these four series have been broken at the year 1830. The results appear in the lower portion of the table. Series VIII and XIV show at least an apparent strengthening of the correlation due to the division of the materials. Improvement is not evident in Series XIII and XVI.

In stressing the smallness of these (generally positive) values, it is proper to emphasize two points:

(*a*) The correlations are between the sun-spot numbers and the growth increments of the same year. It is conceivable that there may be an anticipation or a lag in the biological consequences if solar activity as expressed in sun-spot number can be regarded as a real cause.

(*b*) The coefficients are the raw values, uncorrected for the influence of secular change in growth rate. Correction has not been attempted because of the excessive labor of calculation when grouping of the data can not safely be attempted. Let t = time, s = sun-spot number, r = width of growth rings. The corrected value should be given by the partial correlation coefficient between sun-spot numbers and tree ring dimensions for constant time, i. e.,

$$_tr_{sr} = \frac{r_{sr} - r_{st}r_{rt}}{\sqrt{1-r_{st}^2}\sqrt{1-r_{rt}^2}}$$

Now for data extending over a reasonably long period of time r_{st} should approach 0. General botanical experience would lead us to expect that r_{rt} will be negative in sign. Inspection of the formula will, therefore, suggest that the usual effect of correction will be to raise the values of the coefficients as given here.

Taken as a whole these coefficients indicate a low positive correlation between sun-spot number and tree growth. The relationship is by no means so intimate as many writers imply.

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NOTES, ABSTRACTS, AND REVIEWS

TABLES FOR COMPUTING HARMONIC ANALYSIS

For students in meteorology, physics, engineering, economics, and other branches of science who find it necessary to compute periodograms, Fourier series, or harmonic analyses in other forms, there are now available Dr. Leo W. Pollak's *Rechentafeln zur Harmonischen Analyze* (published by Johann A. Barth, Leipzig). These tables will doubtless facilitate harmonic analysis fully as much as do the well-known Crelle Rechentafeln for multiplication and division.

The harmonic tables are in quarto form of about the same size and general external appearance as the Crelle tables.

Twelve pages of printed German text mention the purposes and advantages of tables for harmonic calculations, citing other publications and discussing the arrangement of the tables in two parts, I and II, with comments on the accuracy and verification of all computations.

Six additional pages, also in German, give general and detailed explanation of the use of the tables, with citations to the literature, concluding with the detailed computation of five examples of single wave forms by mental arithmetic as well as with the aid of computing machines. One example explains how a single higher harmonic (fifth) may be found.

Two of the examples show abridgments of the computations: First, when the considerable number of phase values (35) is odd, and, second, when the relatively large number (32) is divisible by four.

The reviewer can only remark that for a great number of possible users the value of the table would be much enhanced if the text accompanying them were printed in full in the English as well as the German language.

The tables are unique in a typographic sense, because printed from phototyped plates of hand-written original copies.

In problems of the harmonic analysis we must evaluate the amplitude of sine and cosine functions for elemental wave forms having observed or assigned values of the function at widely varying numbers of equidistant phase intervals.

Table 1 provides for every integral number of equidistant intervals from 3 to 40, inclusive, for each of which are tabulated the values of

$$iz = \frac{360°}{\text{n}} z \Big]_{z=0}^{z=(n-1)}$$

The natural and the logarithmic sine and cosine of iz are also given and where required a reference to the page in Table 2 where products are to be found.

Table 2 comprises 120 pairs (pages). Pair 6, for example, is headed,

Sin 38° 34′ 17″.14 cos 51° 25′ 42″.86 = 0.623489*8*

The table gives, to six significant figures, the products of the above number by all numbers from 1 to 1000, tabulated in all respects similar to the well-known Crelle tables. Two pages are obviously required.

A computer must of course become familiar with the requirements of the Fourier analyses and attain some proficiency in the use of these tables before their full value is realized.—*C. F. Marvin.*